Chapter 1

Introduction to the SWMM Environment

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This necessarily brief review features a few highlights from the perspective of an academic marginally involved in the development of SWMM. As a historical sketch it is admittedly poor, covering only what the writer considers to be a few central activities. It was written to help new users understand the peculiarities of the code and manuals, and to plot a path through part of the confusing serial literature. Textbooks, manuals and reports are not covered.

Most urban stormwater code has been written and distributed for commercial reasons. The development of SWMM, its ancestry and its continuing support, on the other hand, is probably unique. Apart from intermittent support of the USEPA, research groups at several different universities, including those of the author, the University of Florida, and Oregon State University, and engineers at agencies and in consulting offices, have spasmodically contributed ideas or more materially to the evolution of SWMM.

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The SWMM environment is a natural consequence of active participation in scientific, technical and engineering conferences, symposia, seminars, workshops and other meetings. Besides workshops and short courses given by (i) the University of Florida, (ii) the USEPA, and (iii) the writer, the more common meetings include:

1. An approximately biennial series of Specialty and Engineering Foundation conferences (both involving the Urban Water Resources Research Council of the American Society of Civil Engineers or ASCE);
2. A series of regular international conferences every three years and;
3. Irregular six-monthly user group conferences in the US and Canada, whose papers are listed at the end of the chapter.

A study of the lists of committee members, invited speakers, authors of papers, and the content of some papers, will inevitably detect some repetition and find a remarkable amount of consistency over the years. Fortunately other consulting engineers, planners, geographers, aquatic biologists and related professionals concerned with urban development and its impact on aquatic environments have contributed equally to the rich literature.

Since the proceedings of the water quality management modellers user conferences are generally more difficult to locate in libraries or elsewhere, this review includes a list of most of the papers presented in that series. The papers cover many topics of intense interest to readers of these proceedings, and nicely encapsulate the changing emphasis over the past two decades. Topics range from concerns with water flows in a remote-batch-mainframe environment, to interdisciplinary ecosystems concerns in the evolving networked-workstation design environment. A crude guide to the papers is provided.

1.1 Introduction

The public domain program known as SWMM was originally the result of generous funding provided by the USEPA. The early contractors were: 1. Metcalf and Eddy Inc. of Palo Alto, 2. University of Florida, and 3. Water Resources Engineers Inc. of Walnut Creek, California. It's important to note that the code has been under more-or-less continuous development for about three decades, almost exclusively at the University of Florida (until 1991) under Wayne Huber's leadership. The manuals were also written there, and produced occasionally in response to EPA contract agreements. But, under Reaganomics, USEPA support fell away over the years, and in the late 80s, it virtually dried up. Nevertheless a few die-hard professors continued to support the code, despite all odds.

Consulting engineers have also contributed to the development, some having selflessly donated code, and others under contract, notably CDM (Camp Dresser and McKee). Their participation is especially important for keeping the development tied to practical problems.

For each major issue of the documentation, the evolving code has been bundled up and given a new version number. Software archaeologists should take care not to infer that the historic versions of the documentation reflect the then contemporary SWMM code; available documentation clearly lags code development by several years.

1.2 USEPA SWMM

The four volumes of the 1971 STORMWATER MANAGEMENT MODEL report marks an early starting point. Two volumes related to the theoretical background, and to code validation. Volume three comprised the first user's manual, and volume four the original source code listing. That program was very limited by comparison with to-day's versions. Version 1 did not include

a COMBINE block. Figure 1.1 is a schematic for version 2 and Figure 1.2 shows the engineering design relationship between its modules. Figure 1.2 is essentially unchanged from that for version 1.

The user's manual for version 2 was published in March 1975. The program still incorporated a RECEIVING block, but no EXTRAN block. The schematic is shown in Figure 1.1.

In November 1977, Interim SWMM documentation was published (still version 2 officially), and it included snowmelt, better continuous simulation, and EXTRAN documentation. The new schematic is presented in Figure 1.3. In November 1981 the user's manual for version 3 was published. The RECEIVING block was deleted, and a separate Addendum for EXTRAN was published under the authorship of CDM of Annandale, Virginia. The program was still big-batch-mainframe oriented, and distributed on 9-track tape. Later, version 3.3 was distributed by the EPA for use on microcomputer. Figure 1.4 is a schematic for version 3. Note that this version did not in fact include a RECEIVING block.

Starting in 1977, the author and his group ported the code to minicomputer and later to microcomputer systems. Free-format input, 80-column output, screen-oriented graphics, error-checking and transparent file handling was added. The documentation was rewritten in user-friendly style, the code stored on diskettes, and the package distributed by CHI as PCSWMM. PCSWMM3.2 was last formally distributed in 1987. A schematic is shown in Figure 1.5, depicting how the program was structured on the 5¼ inch diskettes.

Version 4 was the second EPA version that could run on microcomputers, and appeared with published documentation in August 1988. It was an USEPA response to PCSWMM which was a commercial product, and version 4 included most of the attributes of PCSWMM as well as a wide range of enhancements. The new EPA documentation reflected many of the contributions of PCSWMM, particularly the tables of input data requirements. Figure 1.6 is the schematic for version 4. It was configured for operation on hard disk, but retained much of the big-batch main

Figure 1.1: Schematic for SWMM version 2 (March 1975). Source: Huber, W.C. et al. SWMM User's Manual Version 2, EPA-670/2-75-017 (NTIS PB-257809) EPA Cincinnati OH March 75.

Figure 1.2: Engineering design relationship between SWMM modules (and submodules). Source: Huber, W.C. et al., SWMM User's Manual Version 2, EPA-670/2-75-017 (NTIS PB-257809) EPA Cincinnati, OH March 75.

frame architecture. It was now much better configured for continuous simulation and time-series management, incorporating a RAIN block and a temperature block.

1.3 Derivatives of SWMM

In the early 90s a number of derivative codes became available in the private domain, of which the outstanding examples are EXTRAN-XP and SWMM-XP, developed and distributed by WP Software of Canberra, Australia. The XP codes, originating on a MacIntosh platform, use a graphics-based environment and are the most user-friendly of all the urban stormwater system design codes. The codes now include significant modification of the USEPA code, eliminating the grief involved in getting SWMM running smoothly.

1.4 Serial Literature

In this chapter we deal with the specialised serial literature only; textbooks, manuals, research reports, and other one-off documentation are not covered. Serials here are taken to be the result of more-or-less regular technical meetings, as opposed to (say) a series of unrelated design codes. The Australian meetings and conferences on Urban Stormwater Quality Modelling are not listed here.

1.5 Conference Proceedings

1.5.1. Sanctioned ASCE Urban Water Resources Research Council Meetings

As SWMM was evolving, the literature was growing. Several textbooks appeared, and the University of Kentucky ran an annual

Figure 1.3: Schematic for SWMM version 2 (Nov. 1977). Source: Huber, W.C. et al., Release of EPA SWMM, Nov. 77. Draft Interim Documentation, University of Florida, Dept. of Environmental Engineering Sciences, Gainesville, FL Nov. 1977.

Figure 1.4: Schematic for SWMM version 3 (Nov 1981). Source: Huber W.C. et al., SWMM User's Manual Version 3 EPA-600/2-84-109a (NTIS PB84-198423), Environmental Protection Agency, Cincinnati, OH (4th printing October 1982).

Figure 1.5: Schematic for PCSWMM3.2.

conference on urban hydrology, hydraulics and sediment transport every July from 1976 to 1985.

The Urban Water Resources Research Council (UWRRC) of the ASCE sponsored a number of special meetings, as well as sessions at various ASCE Division Specialty conferences. Every few years a conference was arranged under the close support of the UWRRC by the Engineering Foundation. The proceedings for all these conferences, as well as a number of related manuals, were published by the ASCE. A list of some relevant, focused conferences in the period 1971-89 whose proceedings are

Figure 1.6: Schematic for SWMM version 4 (August 1988).
Source: Huber, W.C. and Dickinson, R.E.
SWMM Version 4 User's Manual. EPA/600/3-88/001a (NTIS PB88-236641) EPA Athens, GA (August 88).

available from the ASCE is provided below. The list is not exhaustive, does not cover conferences with broader coverage than urban stormwater management, and does not include other international conferences, such as those of the Canadian Society of Civil Engineering (CSCE). Copies of the books of proceedings are available from the ASCE at 345 East 47th St, NY, NY 10017.

ASCE SANCTIONED CONFERENCES

DATE	PLACE	TITLE
1989	Davos, Switz.	Urban Stormwater Quality Enhancement - Source Control, Retrofitting, and Combined Sewer Tech.
1988	Potosi, Missouri	Design of Urban Runoff Quality Controls
1986	Hennicker, N.H.	Urban Runoff Quality - Impact & Quality Enhancement Technology
1983	Baltimore, M.D.	Urban Hydrology
1983	Niagara-on-the-Lake, Ont.	Emerging Computer Techniques in Stormwater and Flood Management
1982	Hennicker, N.H.	Stormwater Detention Facilities
1980	Blacksburg, Vir.	Urban Stormwater Management in Coastal Areas
1978	Hennicker, N.H.	Water Problems of Urbanizing Areas
1976	Easton, M.D.	Guide for Prediction Analysis and Use of Urban Stormwater Data
1974	Rindge, N.H.	Urban Runoff Quantity and Quality
1971	Deerfield, Mass.	Urban Water Resources Management

1.5.2. International Meetings Involving IAHR and/or IAWPRC

International meetings were also organised by a joint committee of the International Association for Hydraulic Research and the International Association for Water Pollution Research and Control. Venues were Southampton (UK), Urbana (IL), Gothenburg (Sweden), Lausanne (Switzerland), Osaka (Japan) and (in 1993) Niagara Falls (Ontario). Other smaller, more specialised meetings were held in Dubrovnik, Davos, Montpelier, Wageningen, Duisberg, and elsewhere. The UWRRC was instrumental in arranging participation by US agencies and

academics. The next table lists a selection of those meetings and their titles.

SOME INTERNATIONAL CONFERENCES

DATE PLACE	TITLE	Number of Volumes
Jul 93 Niagara Falls, Ontario	Proc. 6th Int. Conf. on Urban Storm Drainage (to be published)	
Jul 90 Tokyo, Japan	Proc. 5th Int. Conf. on Urban Storm Drainage	3 volumes
Apr 88 Duisburg, West Germany	Hydrological Processes and Water Management in Urban Areas	1 volume
Aug 87 Lausanne, Switzerland	Topics in Urban Stormwater Quality, Planning and Management: Proc. 4th Int. Conf. on Urban Storm Drainage	2 volumes
Apr 86 Dubrovnik, Yugoslavia	Urban Drainage Modelling - Symposium on Comparison of Urban Drainage Models with Real Catchment Data	3 volumes
Aug 85 Montpellier, France	NATO Advanced Science Institute: Urban Runoff Pollution	1 volume
Jun 84 Goteborg, Sweden	Proc. 3rd Int. Conf. on Urban Storm Drainage	4 volumes
Jun 81 Urbana, Illinois	Urban Stormwater Quality Management and Planning: Proc. 2nd Int. Conf. on Urban Storm Drainage	2 volumes
Apr 78 Southampton, United Kingdom	Proc. 1st Int. Conf. on Urban Storm Drainage	1 volume

1.5.3. So-called SWMM User Group Meetings

Early co-operation was established between groups in Canada and the US, and the proceedings of several user group conferences were published in "The Storm Water Management Modeller - a bulletin to the users of the EPA's SWMM". The writer holds copies for meetings held in Toronto, April 1st 1976; in Toronto October 26th 1976; Gainesville (FL) April 4-5 1977; and Milwaukee Nov 3-4 1977. In addition, the Ontario Ministry of the Environment published proceedings, of which the writer holds the following: Toronto, Oct 19-21 1976; and Toronto March 28-30 1977.

Subsequent conferences were then organised by various users, sponsored by the USEPA inter alia, and held approximately twice a year, alternating between Canada and the U.S. The title of the conference became "Stormwater and Water Quality Management Modelling" or similar. The proceedings of the conferences, and sources, as known to the writer, are as follows (in reverse chronology):

Sources for the proceeding USEPA sanctioned conferences:

Nat Tech Info Services (NTIS)	Dr. Paul Wisner
5285 Port Royal Road	Dept of Civil Engineering
Springfield, VA 22161	University of Ottawa
	Ottawa, ON K1N 9B4

Dr. Wm. James	
School of Engineering	Charles Howard & Assoc. Ltd.
University of Guelph	300-1144 Fort Street
Guelph, ON N1G 2W1	Victoria, B.C. V8V 3K8

Ont. Min. of the Environment
Pollution Control Branch
135 St. Clair Avenue, West
Toronto, ON M4V 1P5

**USEPA SANCTIONED
STORMWATER AND WATER QUALITY MANAGEMENT MODELLING CONFERENCES**

DATE	PP	REPORT NUMBER	NTIS NUMBER	SOURCE	PLACE
Feb 92	c600	CHI/U of Guelph		W. James	Toronto, ON
Apr 90	XX	unknown		T.Najarian	Eatontown, NJ
Oct 88	233	EPA-600/9-89-001	PB89 195002/AS	NTIS	Denver,CO
Oct 87	175	Howard Assocs		C. Howard	Victoria, BC
Mar 87	249	EPA-600/9-87-016	PB88-125430	Try NTIS	Denver,CO
Sep 86	463	U of Ottawa		P.Wisner	Toronto, ON
Mar 86	334	EPA-600/9-86-023	PB87-117438	Try NTIS	Orlando,FL
Dec 85	426	CHI-R149		W.James	Toronto, ON
Jan 85	268	EPA-600/9-85-016		NTIS	Gainesville,FL
Sep 84	261	CHI-R128	PB85-228302	W. James	Burlington, ON
Apr 84	298	EPA-600/9-85-003	PB85-168003	Try NTIS	Detroit, MI
Sep 83	274	GREMU 83/02		P. Beron	Montreal, PQ
Jan 83	282	EPA-600/9-83-015	PB84-118454	NTIS	Gainesville,FL
Oct 82	274	U of Ottawa		P. Wisner	Ottawa, ON
Mar 82	298	EPA-600/9-82-015	PB83 145540	NTIS	Washington,DC
Sep 81	551	CHI-R81		W. James	NiagaraFalls,ON
Jan 81	257	CHI-R83		W. James	Austin, TX
Jun 80	238	EPA-600/9-80-064	PB81 173858	NTIS	Toronto, ON
Jan 80	329	EPA-600/9-80-017	PB80 177876	NTIS	Gainesville,FL
May 79	413	EPA-600/9-79-026	PB80 105663	NTIS	Montreal, PQ
Nov 78	238	EPA-600/9-79-003	PB290 742/6BE	NTIS	Annapolis,MD
May 78	244	EPA-600/9-78-019	PB285 993/2BE	NTIS	Ottawa, ON
Mar 77	389	Conf. Proc. No.5		MOE	Toronto, ON
Oct 76	334	Conf. Proc. No.4		MOE	Toronto, ON

1.5.4. SWMM User Group Meeting Papers

Finally, this chapter concludes with a very simple classification of papers of the above irregular water quality model users meetings held in Canada and the US. In the lists following the index tables, each paper two pages or longer is given a "koechel" (an arbitrary pseudo-chronological) number. The coarse indexes are presented first.

Readers who need copies of any papers should contact the above sources, and if difficulties arise, FAX the author at 1-519-836-0227 or 1-519-767-2770.

GROUP TOPICS

GROUP 1: Emerging SWMM environment

- 1.1 Model complexity
- 1.2 Limitations of wet hydrology
- 1.3 Impacts of urbanization
- 1.4 Best management practices

GROUP 2: Stormwater management modelling

- 2.1 History of stormwater management
- 2.2 Brief introduction to various programs
 - 2.21 HSPF
 - 2.22 Receiving water models
 - 2.23 All other models
- 2.3 Managing the modelling: accuracy, disaggregation, synthesis, sensitivity, calibration, validation, interpretation

GROUP 3: The Stormwater Management Model

- 3.1 History
- 3.2 General concepts

GROUP 4: Data management

- 4.1 Time series management
- 4.2 Spatial data management
- 4.3 Statistics

GROUP 5: Urban hydrology

- 5.1 Meteorology
- 5.2 Surface runoff
- 5.3 Groundwater and infiltration
- 5.4 Pollutant buildup and washoff

GROUP 6: Urban hydraulics

- 6.1 Storm sewer networks
- 6.2 Sanitary sewer hydraulics
- 6.3 Pumps, weirs, gates, orifices, diversion structures, outfalls
- 6.4 Surcharged flows

GROUP 7: Pollution control

- 7.1 Detention basins
- 7.2 Pollutant removal

GROUP 8: Continuous modelling**GROUP 9: The near future of stormwater management modelling**

For the list of papers in the above groups, see the following index.

INDEX

GROUP PAPERS

For a description of the groups see the previous table.
 For the titles of following papers, see the following tables.

1

- 1.1: 201; 1816-7; 1922;
 1.2: 1708;
 1.3: 202,204,206; 508,513; 604,610; 705; 809; 907,913,916; 1013; 1101; 1510,1516; 1813; 1918,1920;
 2007; 2105; 2207;
 1.4: 304; 402,405; 502; 710; 915,922,925-6; 1207,1215-6; 1308,1310-1,1316; 1402; 1502; 1606,1617;
 1901,1906,1913; 2005,2104,2205;

2

- 2.1: 203,212-3,215; 301; 1803;
 2.21: 912; 1003; 1315,1317; 1409; 1607-8,1610; 1807; 2111; 2211;
 2.22: 112; 307; 803-4; 905,908,918; 1005; 1205-6; 1404,1407-8,1412,1415-7; 1513; 1611,1614;
 1707,1719-20; 1811,1815,1821; 2112; 2209
 2.23: 114,121,123; 207,209; 305,308-9; 404; 509,511-2,514; 601,615; 702-3,708; 810; 903-4,909,919-20;
 1014; 1105,1113-4; 1202; 1515; 1601,1609,1612; 1712-3,1715-6,1722,1725; 1805,1809-
 10,1818,1822; 1904,1907-12,1917,1924,2001-2,2013,2101,2107,2208,2217;
 2.3: 101,109,115,119-20; 211; 306; 403,409; 501,505; 602,609,611-3; 704; 914; 1001-2,1009;
 1102,1104; 1201,1213; 1312; 1405,1411; 1705-7,1714,1721,1723; 1804; 1919,1923; 2016-7,2206;

3

- 3.1: 410; 1504,1509; 1801; 2203;
 3.2: 102,122; 1802,1806; 1903;

4

- 4.1: 113; 208; 711; 801; 1007; 1112; 1210-1; 1301; 1413-4; 1508; 2110;
 4.2: 1414; 2004; 2214-5;
 4.3: 901,917; 1307; 2210;

5

- 5.1: 110; 503,510; 707; 902; 1011; 1108; 1212,1214; 1406; 1511; 1702-4; 2009; 2216;
 5.2: 103,107,116-7; 205; 603; 706; 1203; 1302; 1604-5; 1808; 1916; 2102; 2202,2218-20;
 5.3: 1701; 2006;
 5.4: 104,108; 506,515; 605,614; 1004,1012; 1209; 1305; 1501; 1702-4; 1812; 1915; 2008,2015; 2109;

6

- 6.1: 406; 701; 1217; 1304; 1709; 1819; 2108; 2221-2;
 6.2: 105,118; 408; 507; 802; 1103,1106,1115; 1306; 2003;
 6.3: 303; 805-6; 1514; 2010-1;
 6.4: 302; 504; 606-7; 1010; 1109; 1303; 1403; 1503; 1711; 1905; 2106; 2201,2204;

7

- 7.1: 407; 709; 808; 911; 1208; 1313; 1410; 1512; 1603; 1718; 1914,1921;
 7.2: 111; 210,214; 401; 807; 906,910,923; 1008,1016; 1107,1110; 1204; 1309,1314; 1505; 1613,1615-6;
 1717,1724; 1814; 1902; 2012,2014; 2213;
 8: 106; 608; 924; 1006,1015; 1506; 1602; 1710; 1820;
 9: 124; 921; 1111; 1401; 1507; 1612; 2103; 2212;
-

STORMWATER AND WATER QUALITY MANAGEMENT MODEL USER MEETING PAPERS

For access to these papers see the list of USEPA-sanctioned conferences.

- 101 Objectives of modelling in urban drainage studies. P.E. Wisner, pp 2-25
 - 102 Introduction to the SWMM. A.R. Perks, pp 26-32
 - 103 SWMM RUNOFF submodel - relationships for quantity simulation. W. Clark, pp 33-38
 - 104 SWMM RUNOFF submodel - relationships for quality simulation. A.F. Roake, pp 39-46
 - 105 SWMM TRANSPORT submodel. P. Ahern, pp 47-49
 - 106 Long-term simulation models. A.R. Perks, pp 50-52
 - 107 Testing runoff models - quantity simulation. P.E. Wisner, pp 53-57
 - 108 Testing SWMM on Canadian watersheds - quantity simulations. H.S. Belore, pp 58-64
 - 109 Lumped simulation. A.R. Perks, pp 65-67
 - 110 Modelling urban snowmelt runoff quantity and quality. H.S. Belore, pp 68-74
 - 111 SWMM STORAGE/TREATMENT submodel- relationships for quality simulation. P.Dick, pp 75-78
 - 112 Receiving water modelling - the RECEIV submodel. A.F. Roake, pp 79-82
 - 113 Data analysis model. L. Pataky, pp 83-85
 - 114 Selection of models for urban drainage problems: technical aspects and nontechnical constraints.
P.E. Wisner, A.F. Ashamala & P.A. Ahern, pp 86-108
 - 115 Methodology of preparing detailed subcatchment data. pp 110-129
 - 116 RUNOFF block workshop example no. 1. pp 130-155
 - 117 RUNOFF block workshop examples no. 2 and no. 3. pp 156-176
 - 118 TRANSPORT example problem. pp 177-202
 - 119 Lumping demonstration - Brucewood. pp 203-208
 - 120 Lumping workshop example. pp 209-252
 - 121 STORM workshop example. pp 253-258
 - 122 Input data description for SWMM. pp 269-304
 - 123 Input data description for STORM. pp 305-330
 - 124 Interfacing urban storm water models. pp 331-334
-

2 March 1977:

- 201 Introduction. G.H. Mills, pp 1-12
 - 202 Urban drainage problems - an overview. D.H. Waller, pp 13-32
 - 203 A municipal engineer's view of urban drainage. W.M. Swann, pp 33-46
 - 204 Water quality aspects of urban runoff. D. Weatherbe & Z. Novak, pp 47-123
 - 205 Hydrological aspects of urban drainage. I.F. Loran, pp 124-146
 - 206 Political aspects of urban drainage. L.D. House, pp 147-158
 - 207 A review of urban runoff models. A.R. Perks, pp 59-172
 - 208 Data collection, instrumentation & verification of models. J. Marsalek, pp 173-200
 - 209 Application of computer models for stormwater management. P.E. Wisner, pp 201-219
 - 210 Treatment technology for urban runoff. F.A. Tonelli, pp 220-248
 - 211 Systems demonstration in St. Thomas. W.E. Clarke & R.W. Kuzyk, pp 249-260
 - 212 Urban drainage design for new development. P.E. Theil, pp 261-299
 - 213 Urban drainage practices in Canada. K.W. Moore, pp 300-334
 - 214 Erosion control methods during construction. J.J. Armstrong, pp 335-374
 - 215 Introduction to the "Manual of practice on urban drainage". P. Seto, pp 375-389
-

3 May 1978:

- 301 Stormwater management demonstration study in St. Thomas, ON. W.G. Clarke, W.L. Knowles & R.W. Kuzyk, pp 1-30
- 302 Application of SWMM-EXTRAN for the analysis of existing urban drainage systems. C.W. Eicher, pp 31-48
- 303 CSO facilities planning using a macroscopic model. J.A. Lager, E.J. FinnEwre & G.B. Otte, pp 49-65
- 304 Stormwater management modelling and land development projects. P.E. Wisner, pp 66-84
- 305 Application of STORM to assess the impact of an urbanizing area. C. Brice, pp 85-124
- 306 Methodology for calibrating stormwater models. T.K. Jewell, T.J. Nurmo & D.D. Adrian, pp 125-173

- 307 A simplified continuous receiving water quality model. M.A. Medina, Jr., pp 174-208
 308 Use of the HEC model STORM for sewer inflow removal/treatment cost effective analyses in 3 selected localities. R.T. Prosser & H.M. Shapiro, pp 209-227
 309 Verification and calibration of ILLUDAS. F.I. Lorant & C. Doherty, pp 228-237
-

4 November 1978:

- 401 Revised SWMM STORAGE/TREATMENT block. S.J. Nix, J.P. Heaney & W.C. Huber, pp 1-27
 402 On-site control of nonpoint source pollution. R.H. McCuen, pp 28-38
 403 Stormwater modelling applications. A.R. Perks, pp 39-49
 404 Model for selection of stormwater control alternatives. R. Bedrosyan & J. Ganczarczyk, pp 50-87
 405 Methodology for evaluating agricultural BMPs. J. Kuhner, W.W. Walker & J.J. Wineman, pp 88-104
 406 Computer simulation of flood relief works utilizing inlet control and detention storage. P. E. Theil & A. M. Candaras, pp 105-130
 407 Analysis of detention basin systems. R.G. Mein, pp 131-146
 408 CSO facilities planning in Cincinnati using SWMM (a case study). J.D. Sharon, pp 147-189
 409 SWMM usage in facilities planning. G.D. Cole, L.W. Varner, & J.W. Shutt, pp 190-217
 410 A pre- and post-processing program package for SWMM. W. James, pp 218-233
-

5 May 1979:

- 501 Determination of basin characteristics for an urban distributed routing rainfall-runoff model. W.M. Alley & J.E. Veenhuis, pp 1-27
 502 Evaluation of proposed urban runoff control alternatives. G. LeClerc, pp 28-46
 503 Summary - seminar on the design storm concept. S.G. Walesh, pp 47-54
 504 Use of RUNOFF/EXTRAN for hydraulic analysis of urban drainage systems. R.E.G. Sprenger & C.E. Bright, pp 55-87
 505 Simplified segmentation of an urban catchment for urban runoff simulation with SWMM. P. Purenne, G. Courchesne & G. LeClerc, pp 88-111
 506 Water quality prediction for urban runoff - an alternative approach. E.V. Diniz, pp 112-134
 507 Wastewater interception on the Communaute Urbaine de Montreal (CUM) territory. G. Paquin, pp 135-153
 508 Procedure for the establishment of statewide wasteload allocations. R.A. Hawkins, B.F. Malloy & J.L. Pavoni, pp 154-173
 509 CUM'S simplified hydrograph method for determining urban runoff. C. Mitci, H.N. Nguyen Van & M. Osseyrane, pp 174-200
 510 Feasibility of storm tracking for automatic control of combined sewer systems. V.T.M. Nguyen, M.B. McPherson, pp 201-236
 511 IMPSWM. P.E. Wisner & A.M. Kassem, pp 237-241
 512 Description and application of an interactive mini-computer version of the ILLUDAS model. G. Patry, L. Raymond, & G. Marchi, pp 242-274
 513 Modelling urban and agricultural development, hydrology and eutrophication in a Louisiana swamp forest ecosystem. C. Hopkins & J. Day, Jr., pp 275-319
 514 Development and implementation of an urban-rural subcatchment hydrologic model (SUBHYD) for discrete and continuous simulations on a microcomputer. L. Thompson & J. Sykes, pp 320-361
 515 Rainfall-runoff modelling of flow and total nitrogen from two localities in the Denver, Colorado, metropolitan area. W. Alley & S. Ellis, pp 362-403
-

6 January 1980:

- 601 Stormwater management planning using the Penn State runoff model. D.F. Lakatos, pp 1-16
 602 Computer modelling for watershed management in northern Virginia. H.A. Bonuccelli, J.P. Hartigan, & D.F. Biggers, pp 17-40
 603 Comparison of design peak flows calculated by the rational method and the EPA-SWMM model. P.E. Wisner, A.M. Kassem, & P. Cheung, pp 41-74
 604 Urban runoff quality in metropolitan Toronto. F.I. Lorant, pp 75-92
 605 An examination of SWMM surface-runoff-quality algorithms. W.M. Alley, pp 93-110

- 606 The use of SWMM to economically model surcharged combined sewer systems. W.M. Parker, III, pp 111-131
- 607 Improvements in EXTRAN. L.A. Roesner, A.M. Kassem, & P.E. Wisner, pp 132-141
- 608 CSO impact determination by long term simulation. H.M. Shapiro, J.B. Blenk, & M.P. Allen, pp 142-189
- 609 Towards standards for computer-based municipal drainage studies. W. James & M.A. Robinson, pp 190-206
- 610 Simulation of effects of urbanization on stormwater hydrographs and pollutographs - a regionalized parametric approach. D.E. Overton, W.L. Troxler & E.C. Crosby, pp 207-222
- 611 Stormwater modelling applications in the city of Edmonton. M. Ahmad, pp 223-242
- 612 Stormwater runoff modelling of the Tampa Palms property. K. Smolenyak, pp 243-252
- 613 Drainage system design and analysis of the Tampa Palms property. R.J. Motchkavitz, pp 263-285
- 614 Water quality in the first, second and third order streams of an upland and forested wetland watershed. C.M. Courtney, pp 286-305
- 615 Implementation of storm water management models: pros and cons of standardization. P.E. Wisner, A.M. Kassem, & P. Cheung, pp 306-325

7 June 1980:

- 701 Combined sewer system analysis using STORM and SWMM for the city of Cornwall. J.C. Anderson, pp 1-22
- 702 Considerations regarding the application of SCS TR-55 procedures for runoff computations. P.E. Wisner, S. Gupta, & A.M. Kassem, pp 23-44
- 703 A simplified stormwater quantity and quality model. S. Sarikelle & Y.T. Chuang, pp 45-63
- 704 Methodology for 'lumped' SWMM modelling. M. Ahmad, pp 64-79
- 705 Characterization, magnitude and impact of urban runoff in the Grand River basin. S.W. Singer & S.K. So, pp 80-120
- 706 Development of an urban highway storm drainage model based on SWMM. R.J. Dever & L.A. Roesner, pp 121-132
- 707 Kinematic design storms incorporating spatial and time averaging. W. James & J.J. Drake, pp 133-149
- 708 Hydrograph synthesis by the HNV-SBUH method utilizing a programmable calculator. B.L. Golding, pp 150-177
- 709 Detention lake application in master drainage planning. A.T.Fok & S.H.Tan, pp 178-199
- 710 Alternative urban flood relief measures: a case study, city of Regina, Saskatchewan, Canada. A.M. Candaras, pp 200-211
- 711 A long-term data base for the investigation of urban runoff pollution. W.F. Geiger, pp 212-233

8 January 1981:

- 801 An overview of the national urban runoff program Lake Austin study. F.J. Castaldi, M.O. Hinson, & L.F. Tischler, pp 1-34
- 802 Combined sewer overflow modelling in the Detroit 201 study using SWMM. J.A. Anderson, C.D. Harlow, J. Baranec, & H.M. Anderson, pp 35-55
- 803 One dimensional water quality models for dynamic, small rivers: the Rouge River. C.D. Barlow, E. Jamshidi, R.H. Kummier, J.G. Frith, & J.A. Anderson, pp 56-83
- 804 Two dimensional water quality models for dynamic major rivers: the Detroit River. R.E. Kummier, G. Roginski, C.S. Liang, S. Winkler, & J.A. Anderson, pp 84-118
- 805 Co-ordinated multiprocessing for real-time control of urban drainage. M. Robinson & W. James, pp 119-140
- 806 SWMM compatible algorithm for side weir structures. W. James & H. Mitri, pp 141-157
- 807 Algorithm for sediment deposition and resuspension in a one dimensional zone between an outfall and a receiving water. W. James & A. ElZawhry, pp 158-170
- 808 Effect of urban nonpoint loads upon concentration of metals in the sediment deposits of Town Lake. J.D. Miertschin & M.S. Peters, pp 171-198
- 809 Linkage of RECEIV hydrodynamics with dynamic estuary model water quality. R.B. Ambrose, Jr. & T.L. Prather, pp 199-221
- 810 Considerations regarding the application of SCS TR-55 procedures for runoff computations. Discussion by R.H. McCuen, pp 222-239; Reply by P. E. Wisner, S. Gupta, & A.M. Kassem, pp 240-257

9 September 1981:

- 901 Uncertainty analysis in stormwater and water quality modelling. R.H. Kummeler, J.G. Frith, C.S. Liang & J.A. Anderson, pp 1-54
- 902 Implications of storm dynamics on design storm inputs. W.James, & Z.Shifter, pp 55-78
- 903 A review of NCASI's mathematical water quality modelling program. R.C. Whittemore, J.S. Hovis & J.J. McKeown, pp 79-94
- 904 Stream modelling analysis with field measurements of reaeration rate constant (central New York). C.C.K. Liu, pp 95-110
- 905 Desk top estuary water quality modelling - a case study (Kennebunkport River). A.K. Deb & D. McCall, pp 111-124
- 906 Justification of advanced waste treatment at Mansfield, Ohio. A.S. French & S. Amragy, pp 125-158
- 907 Dynamic modelling used to develop waste load allocations (Savannah, GA). D.R. Bingham & R.A. Moore, pp 159-174
- 908 Calibration of the RECEIV model in a well mixed tidal estuary using the equilibrium procedure. I.B. Chou, pp 175-194
- 909 TEMSTAT - a model for statistically evaluating the variability of river temperatures. D.J. Murray, & D.R. Schregardus, pp 195-204
- 910 Pollutant removal in stormwater detention basins. R.A. Ferrara, P. Witkowski, & A. Hildick-Smith, pp 205-226
- 911 Cost analysis of a runoff detention policy. P.F. Lemieux & M. Codere, pp 227-242
- 912 Calibration of pesticide behaviour on a Georgia agricultural watershed using HSP-F. D.A. Woodruff, D.R. Gaboury, R.J. Hughto, & G.K. Young, pp 243-256
- 913 Master drainageway planning study, Boxelder Creek, CO. J.R. Kimzey, R.A. Burns & W.S. Liang, pp 257-270
- 914 Application of urban runoff models to cities in Saudi Arabia. A.M.Ishaq, pp 271-282
- 915 A comprehensive watershed management plan for Tinker's Creek - a case history in Prince George's County, MD. S. Udhiri, M. Vasa, M. Wallace, & K.D. Nambudripad, pp 283-294
- 916 Preliminary analysis of CSO impact on lower Rahway river water quality. T.O. Najarian, & V.K. Gunawardana, pp 295-314
- 917 An application of a closed form approximation for frequency of urban runoff volumes to a unique storm drainage problem. R.Bishop & M.Cosburn, pp 315-332
- 918 Modelling applications using QUAL-II and STORM. A.C. Rowney, J.C. Anderson, & A.R. Perks, pp 333-344
- 919 Application of SUBHYD to the Hamilton test catchment. L. Thompson & K. Dennison, pp 345-370
- 920 TRANQUAL - two dimensional modelling of transport water quality processes. R.B. Taylor & J.R. Pagenkopf, pp 371-398
- 921 An integrated modelling approach for evaluating CSO treatment alternatives. A.Dee, T. McConville, & C. C-S Song, pp 399-426
- 922 Evaluation of relief alternatives for combined sewer systems. A.Ashmala & M. Ahmad, pp 427-454
- 923 Persistence of toxic substances in stormwater - a case study. J.Wong & J. Marsalek, pp 455-468
- 924 Continuous SWMM quality modelling using Env. Can. data files. M.Robinson & W. James, pp 469-492
- 925 Investigation of management alternatives for relieving CSOs for the city of Hamilton. D.Henry & W. James, pp 493-512
- 926 Agricultural non-point source pollution and control in the Grand River basin. S.N. Singer & S.K. So, pp 513-544

10 March 1982:

- 1001 A study of the selection, calibration and verification of mathematical water quality model. R.C. Whittemore, J.S. Hovis, & J.J. McKeown, pp 1-35
- 1002 An assessment of the measurement uncertainty in the estimation of stream reaeration rate coefficients using direct tracer techniques. J.S. Hovis, R.C. Whittemore, L.C. Brown, & J.J. McKeown, pp 36-53
- 1003 Calibration of hydrology and sediment transport on small agricultural watersheds using HSPF. D.E.Schafer, D.A. Woodruff, R.J. Hughto, & G.K. Young, pp 54-68
- 1004 Hydrologic modelling studies of pollutant loadings and transport in large river basins. A.Cavacas, J.P.Hartigan, E.Southerland, & J.A.Friedman, pp 69-89
- 1005 Continuous DO response predicted using CSPSS is verified for Springfield, MI. J.E. Scholl & R.L. Wycoff, pp 90-100

- 1006 Use of continuous simulation model calibration techniques to develop nonpoint pollution loading factors. J.P. Hartigan, T.F. Quasebarth, & E. Southerland, pp 101-127
- 1007 Hydrometeorological data acquisition: innovative, high-resolution programmable instrumentation for stormwater management. W. James, H. Haro, M.A. Robinson, D. Henry, & R. Kitai, pp 128-151
- 1008 The separation of boundary layer and flow turbulence of center-feed circular sedimentation basins. T. Yin, pp 152-161
- 1009 Dynamic model adjustment. D. Hoang, pp 162-178
- 1010 An improved surcharge computation in EXTRAN. J.A. Aldrich & L.A. Roesner, pp 179-190
- 1011 Preparing a design storm. S.A. McKelvie, pp 191-209
- 1012 A predictive model for highway runoff pollutant concentrations and loadings. B.W. Mar & R.G. Horner, pp 210-229
- 1013 Chimney Hill off-site drainage study. J.M. Normann & E.R. Estes III, pp 229-247
- 1014 Desk-top methodology for nonpoint source load evaluation. A.K. Deb, pp 248-259
- 1015 Continuous simulation of instream fecal coliform bacteria. A.C. Rowney & L.A. Roesner, pp 260-273
- 1016 Atmospheric pollution in relation to storm water quality modelling: literature review for an industrial city. B. Shivalingaiah & W. James; pp 274-295

11 October 1982:

- 1101 SWMM modelling for the Detroit 201 final facilities plan. R.H. Kummier, pp 1-35
- 1102 Calibration strategies for SWMM modelling of a combined sewer system. L.C. Alvarado, pp 36-50
- 1103 Infiltration/inflow modelling for the East Bay (Oakland-Berkeley area) I/I study. P.R. Giguere & G.C. Riek, pp 51-76
- 1104 Issues related to mathematical water quality modelling management. R.C. Whittemore, pp 77-88
- 1105 REGQUAL: a useful tool for analysis of combined sewer overflows. J.M. Kennedy & J.D. Sharon, pp 89-103
- 1106 Development and application of Edmonton sanitary trunk system model. M. Ahmad, S. Vatagodakumbura, & R. Choudhry, pp 104-131
- 1107 Dual purpose detention tank for pollution control and flood relief. F.-H. Lai, H.L. Kaufman & U.A. Milletari, pp 132-145
- 1108 Integrity of rainfall time series for models of existing combined sewer system. W. James, D. Henry & H. Haro, pp 146-159
- 1109 Using models to evaluate alternatives for surcharge sewers. N.U. Schultz & R.M. Videkovich, pp 160-174
- 1110 On the performances of swirl concentrator. D. Delmas, pp 175-185
- 1111 Mathematical modelling of coliforms in combined sewer discharges. E.A. McBean, R. Bishop, A. Ashamalla & M. Ahmad, pp 186-202
- 1112 Receiving water quality data base for model testing. W.C. Huber & D.F. MacIntyre, pp 203-211
- 1113 The Piscataway Creek watershed model: a stormwater and nonpoint source management tool. M.P. Sullivan & T.R. Schueler, pp 212-224
- 1114 The IMPSWM procedures for urban drainage modelling and some applications. P.E. Wisner, pp 225-248
- 1115 Evaluation of inflow/infiltration controls for Stratford Ontario. W.M. Wong & G. Zukovs, pp 249-274

12 January 1983:

- 1201 Project success - sensitivity to project assumptions. A. Knepp & G. Wood, pp 1-21
- 1202 Application of the STORM model to design problems in Singapore and Kaohsiung, Republic of China. B.M. Harley, pp 22-42
- 1203 An attempt to implement SWMM in Tunisia. J. Niemczynowicz, pp 43-52
- 1204 The sediment-water interface in modelling pesticides in sedimentation ponds. R.A. Ferrara & P. Jaffe, pp 53-64
- 1205 A mixing zone model for conservative parameters. M.R. Hutcheson, pp 65-86
- 1206 Some recent adaptations and applications of QUAL-II in the northeast. W.W. Walker, Jr., pp 87-101
- 1207 A review of model use in evaluating nonpoint source loads from forest management activities. G.G. Ice & R.C. Whittemore, pp 102-122
- 1208 Detention pond sizing to achieve water quality objectives. R.K. Wells, pp 123-145
- 1209 A mechanistic simulation for transport of non-point source pollutants. D.B. Simons, R.-M. Li & K.G. Eggert, pp 146-160
- 1210 Data management for continuous hydrologic simulation. J.S. Wu, pp 161-176

- 1211 Estimation of missing values in monthly rainfall series. E. Foufoula, pp 177-191
 - 1212 Areal-intensity-duration-frequency curves - a possible way of improving the rainfall input. J. Niemczynowicz, pp 192-201
 - 1213 Hydrological regionalization: a question of problem & scale. I. Simmers & E. Seyhan, pp 202-214
 - 1214 Snowmelt induced urban runoff in northern Sweden. L. Bengtsson, pp 215-236
 - 1215 An advancement in hydraulic modelling of porous pavement facilities. G. Goforth, pp 237-254
 - 1216 Planning and implementation of regional stormwater management facilities in Montgomery County, Maryland. J.M.Crouse, V.H.Berg, & L.J.Mitchell, pp 255-271
 - 1217 Storm sewer design optimization. D. Hoang, pp 272-280
-

13 November 1983:

- 1301 Rainfall/runoff relationship from the NURP urban runoff database. E.D. Driscoll, pp 1-15.
 - 1302 Synthèse des crues pluviales des petits bassins versants du Québec. (Synthesis of small watersheds high flows in Québec). V.D. Hoang, pp 16-31.
 - 1303 Storm surge prediction model and its application to a combined trunk sewer system. A.K. Bhattacharyya & D.L. Fread, pp 32-46.
 - 1304 Présentation du modèle de propagation en conduite du système S.E.R.A.I.L. (Presentation of the routing model of the S.E.R.A.I.L. system). B. Chocat, S. Barraud, & S. Thibault, pp 47-63
 - 1305 Enhancements to SWMM3 Runoff Quality Algorithms. B. Shivalingaiah, M. Robinson, & W. James, pp 64-74
 - 1306 Relation qualité-débit dans un réseau unitaire. (Quality-Discharge Relationships in a Combined Sewer System). J.L. Galand, F. Briere, J. Rousselle, & P. Boron, pp 75-95
 - 1307 Estimation of Water Quality Criteria Violation Frequencies using Pearson Percentiles. L.A. Rossman, pp 96-111
 - 1308 Etude du contrôle en temps réel d'un intercepteur unitaire. (Study of Real-Time Control of a Combined Interceptor). P. Boron, F. Briere, J. Rousselle, & J.P. Riley, pp 112-127
 - 1309 Controlling Phosphorus in Stormwater Runoff: Irondequoit Bay, New York - A Case Study. D.J. Carleo, pp 128-142
 - 1310 Utilisation de SWMM pour la ville de Saint-Laurent. (Utilization of SWMM for the City of Saint-Laurent). M. Larocque, pp 143-158
 - 1311 SWMM Modelling of CSO Control Alternatives for Ecorse Creek. R.H. Kummner, J.G. Frith, C.-S. Liang, R.L. Wilson, & S.E. Williams, pp 159-175
 - 1312 On the Application of a Semi-Distributed Physically-Based Model: A Case Study. E. Seyhan, I. Simmers, & A.A. van de Griend, pp 176-189
 - 1313 Design préliminaire d'un bassin de rétention des eaux pluviales. (Preliminary Design of a Stormwater Detention Basin). P.F. Lemieux, pp 190-204
 - 1314 Élément de contrôle de débit et dégrilleurs pour eaux d'orage. (Discharge Control Device and Stormwater Screens). G. Meunier, pp 205-221
 - 1315 Simulation of Fecal Coliform Bacteria Using HSPF. R. Kolomeychuk, & B. Kalanda, pp 222-234
 - 1316 Modelling Water Quality and the Effects of Agricultural BMPs in the Iowa River Basin. B.R. Bicknell & A.S. Donigan, Jr, pp 235-254
 - 1317 Lake Manatee Watershed Water Resources Evaluation using HSPF. J.A. Song, G.F. Rawl, & W.R. Howard, pp 255-270
-

14 April 1984:

- 1401 Milwaukee's integrated modelling approach to water quality and sewer system analysis. N.U. Schultz, & G.A. Gagnon, pp 1-14
- 1402 Using a Timex-Sinclair 1000 microcomputer for real-time control of CSOs. M. Stirrup & W. James, pp 15-30
- 1403 Hydraulic modelling with SWMM in an unsteady pressure flow regime. J.D. Perry & T.P. Finn, pp 31-46
- 1404 A lake acidification model using WASP. W.-S. Lung, pp 47-66
- 1405 Sensitivity analysis of SWMM predictions on water quality in the Detroit River. A. El-Sharkawy & R.H. Kummner, pp 67-80
- 1406 RAINPAK - a program package for analysis of storm dynamics in computing rainfall inputs. W. James & R. Scheckenberger, pp 81-100

- 1407 Development of flows and loads for steady-state estuary models: Tampa Bay case study. S.A. Hanson & J.P. Hartigan, pp 101-120
- 1408 WATER SCREEN - a microcomputer program for estimating nutrient and pollutant loadings. B.L. Bird, & K.M. Conaway, pp 121-146
- 1409 Simulation of the stormwater and water quality attributes of ponds with HSPF. M.P. Sullivan & T.R. Schueler, pp 147-163
- 1410 Kinematic analysis of detention storage. D. Stephenson, pp 163-174
- 1411 The need to validate hydrologic models. S. Udhiri, pp 175-188
- 1412 Modelling of a negatively buoyant thermal discharge in an estuarine environment. A.K. Deb & J.K. Snyder, pp 189-204
- 1413 Rainfall data acquisition and processing using Apple II workalikes. M. Robinson & W. James, pp 205-216
- 1414 CHGTSM - a combined hydrologic time series and topographic data base manager. W. James & A. Unal, pp 217-232
- 1415 Modifications to the QUAL-2 (SEMCOG) water quality model. R.C. Whittemore, & L.C. Brown, pp 233-248
- 1416 Predicting the recreation coefficient for Ohio streams. D.S. Skalsky, L.D. Fischer, & S. Amragy, pp 249-272
- 1417 Water temperature modelling: a practical guide. P. Shanahan, pp 273-294

15 September 1984:

- 1501 Assessment of surface and subsurface water quality impacts of proposed residential development. T.O.Najarian, V.K.Gunawardana, & M.L.Thatcher, pp 1-14
- 1502 Scarborough tackles its flooding problems. S.A. McKelvie, pp 15-20
- 1503 Application of SWMM-EXTRAN to a coastal flooding situation. A.R. Perks & P.W. Cheung, pp 21-38
- 1504 PCSWMM3 - version 3 of the EXEC, RUNOFF and EXTRAN blocks, adapted for the IBM-PC. W. James & M. Robinson, pp 39-52
- 1505 The SWMM STORAGE/TREATMENT block for the IBM-PC. D.H.Gancarz & W.C.Huber, pp 53-58
- 1506 Continuous variable resolution stormwater modelling on a microcomputer. M. Robinson & W. James, pp 59-74
- 1507 User interfacing techniques for interactive hydrologic models on microcomputers. J.B. Bontje, I.K. Ballantyne, & B.J. Adams, pp 75-90
- 1508 Centralised time series management programs for continuous SWMM3 on personal microcomputers. A. Unal & W. James, pp 91-100
- 1509 SWMM3 program measurement for optimal use of a local area personal microcomputer network. A. Unal & W. James, pp 101-110
- 1510 Flood management in Ontario. P.N. Gryniewski, pp 111-122
- 1511 Microcomputer processing and display of radar-derived rainfall data and its application in runoff modelling. J.D. Bonser & W.F. Caselton, pp 123-136
- 1512 Flow balancing method for stormwater and combined sewer overflow. P. Stevers, pp 137-153
- 1513 Application of a river dispersion model - RIVMIX. L.J.D. Alexander, pp 153-164
- 1514 Routing hydrographs through gates by a computer program developed for personal computers. K.B. Lee, pp 165-175
- 1515 Implementation of microcomputers for SWMM studies in Canadian municipalities. A. Brodie, A. Lam, & P. Wisner, pp 176-210
- 1516 Development of water management strategy for the Humber river. D.G. Weatherbe & Z. Novak, pp 211-257

16 January 1985:

- 1601 Stormwater management by microcomputer. B.A. Christensen & A.D. Tilton, pp 1-12
- 1602 An affordable alternative to a mainframe computer environment for continuous modelling. W. James & M. Robinson, pp 13-30
- 1603 Multiobjective design of stormwater impoundments. E.A. McBean, pp 31-44
- 1604 Determination of runoff characteristics of flatwood watersheds. K.L. Campbell, J.C. Capece, & L.B. Baldwin, pp 45-59
- 1605 Stormwater management model application to a peatlands region in coastal North Carolina. R.E. Dickinson, W. Pandorf, & L.J. Danek, pp 60-68

- 1606 Area-wide strategies for stormwater management in Switzerland: case study Glattal. V. Krejci & W.Gujer, pp 69-86
- 1607 The impact of "snow" addition on watershed analysis using HSPF. S. Udhiri, M-S. Cheng, & R.L. Powell, pp 87-114
- 1608 Use of HSPF to simulate the dynamics of phosphorus in floodplain wetlands over a wide range of hydrologic regimes. I.C. Nichols & M.P. Timpe, pp 115-132
- 1609 Simulation of a regional water supply with aquifer storage. R.L. Wycoff, pp 133-143
- 1610 Simulation of possible effects of deep pumping on surface hydrology using HSPF. C.N. Hicks, W.C. Huber, & J.P. Heaney, pp 144-156
- 1611 Hydrodynamic and water quality simulations in an estuary with multiple ocean boundaries. I.B. Chou & L.J. Danek, pp 157-178
- 1612 Modelling estuarine phytoplankton-nutrient dynamics using microcomputers. W-S. Lung, pp 179-194
- 1613 Application of factor analysis to management of impoundment water quality. C.D. Pollman & R.E. Dickinson, pp 195-202
- 1614 The application of QUAL-II to aid resource allocation on the River Blackwater, England. B. Crabtree, I. Cluckie, P. Crockett, & C. Forster, pp 208-230
- 1615 Techniques and software for reservoir eutrophication assessment. W.W. Walker Jr., pp 231-240
- 1616 Modelling of phosphorus concentrations from diffuse sources. D.J. Andrews, K.K.S. Bhatia, & E.A. McBean, pp 241-256
- 1617 A model for assessing the cost-effectiveness of agricultural BMP implementation programs on two Florida basins. C.D. Heatwole, A.B. Bottcher, & L.B. Baldwin, pp 257-264

17 December 1985:

- 1701 A subsurface drainage module for the SWMM RUNOFF block. V.A. Gagliardo & W.C. Huber, pp 1-8
- 1702 Weather radar for flood forecasting: sensitivity analysis and parameter estimation. N. Kouwen & G. Garland, pp 9-28
- 1703 Dynamics of storms on the western shore of lake Ontario. P. Nimrichter & W. James, pp 29-60
- 1704 A 1-hour urban design storm for Canada. W.E. Watt, K.C.A. Chow, W.D. Hogg, & K.W. Latham, pp 61-81
- 1705 Uncertainty analysis in mathematical water quality modelling. J.H. Hwang, pp 81-100
- 1706 A database environment and sensitivity framework for continuous modelling. K.D. Dennison & W. James, pp 101-124
- 1707 Uncertainty analysis using QUAL2E. L.C. Brown, pp 125-140
- 1708 Physical modelling of urban runoff. I. Muzak, pp 141-154
- 1709 Inlet control or sewer separation. P.E. Theil & D.E. Maunder, pp 155-168
- 1710 Distributed continuous hydrologic processing using microcomputer networks. A. Unal & W. James, pp 169-180
- 1711 Pressure transients during the transition from gravity to surcharged flow in storm sewers. J. McCorquodale & J. Li, pp 181-186
- 1712 New improvements with ILLUDAS. P.F. Lemieux & R. Auger, pp 187-196
- 1713 SYNHYD: synthetic rainfall-runoff model for the IBM-personal computer. G. Aron, pp 197-214
- 1714 Recent studies on the comparison of in-situ and laboratory sediment oxygen demand measurement techniques. R.C. Whitemore & D.-X. Ren, pp 215-222
- 1715 The use of Lotus SYMPHONY in water quality modelling. S.L. Yu & T.S. Tisdale, pp 223-230
- 1716 QUALHYMO - an alternative continuous quality quantity simulation model. P.E. Wisner & A.C. Rowney, pp 231-256
- 1717 A trajectory model for analyzing sediment trapping efficiencies in storm water detention basins. J.S. Wu & R.C. Ahlert, pp 257-284
- 1718 Preservation of an effective dual purpose stormwater control lake. A C Rowney & R. Denham, pp 265-293
- 1719 Two-dimensional finite-time multiple source water quality model for lakeshore-recreational beaches. T. P. Gowda & M. D. Palmer, pp 293-314
- 1720 Dynamic behaviour of stratified flow. A. E. Dudek Ronan, J. C. Cataldo, pp 315-326
- 1721 Adaptation of uncertainties in a nonlinear time-varying parameters storm runoff prediction model. L. A. Logan, pp 327-352
- 1722 A microcomputer based analysis of the hydrologic input of the Hamilton Redhill Creek expressway. L. Thompson, pp 353-372
- 1723 Extended expert system. A. R. Dunn & W. James, pp 373-380
- 1724 Optimizing reservoirs operations to satisfy wastewater assimilation. L. A. Logan, pp 381-404

26 INTRODUCTION TO THE SWMM ENVIRONMENT

1725 Testing of OTTHYMO on twenty watersheds. P. Wisner and D. Consuegra, pp 405-425

18 March 1986:

- 1801 Porting mainframe-based numerical models to microcomputers: a case study using the EPA SWMM. R.M. Baker & K.J. Brazauskas, pp 1-19
- 1802 Portability, maintenance and FORTRAN programming style. T.O. Barnwell, Jr. & D. Disney, pp 20-27
- 1803 Considerations on use of microcomputer models for stormwater management. P.E. Wisner, D. Consuegra, H. Frazer, & A. Lam, pp 28-44
- 1804 PC software for computational hydrology. W. James, M. Robinson, & M. Stirrup, pp 45-57
- 1805 DABRO: a basic language program for hydrograph computation. B.L. Golding, pp 58-79
- 1806 Application of a Lotus spreadsheet for a SWMM pre-processor. S.W. Miles & J.P. Heaney, pp 80-92
- 1807 Impact of extensive irrigation pumpage on streamflow by HSPF. A.K. Nath, pp 93-108
- 1808 The use of SWMM to predict runoff from natural watersheds in Florida. W.C. Downs, J.P. Dobson, & R.E. Wiles, pp 109-120
- 1809 A simplified water quality computer program for regional stormwater management site evaluation. J.M. Crouse & M.H. Helfrich, pp 121-127
- 1810 Development of the HAZPRED model. G. Zukovs, J. Kollar, & M. Shanahan, pp 128-146
- 1811 Alternative calibration of the QUAL-TX model for the upper Trinity River. R. McCarthy, pp 147-156
- 1812 Lognormality of point and nonpoint source pollutant concentrations. E.D. Driscoll, pp 157-176
- 1813 Pollution from highway runoff - preliminary results. P.E. Shelley & D.R. Gaboury, pp 177-192
- 1814 Effectiveness of detention/retention basins for removal of heavy metals in highway runoff. H.H. Harper, Y.A. Yousef, & M.P. Wanielista, pp 193-218
- 1815 Simple trophic state models and their use in wasteload allocations in Florida. R.W. Ogbunr, P.L. Brezonik, & B.W. Breedlove, pp 219-234
- 1816 Model complexity for trophic state simulation in reservoirs. R.A. Ferrara & T.T. Griffin, pp 235-254
- 1817 F.D.O.T. drainage manual: why "drainage" in an age of "stormwater management"? E.G. Ringe, pp 255-262
- 1818 Application of the OTTSWMM model for relief sewer study in Laval, Quebec. R. Roussel, J.C. Pigeon, & J.R. Noisieux, pp 263-274
- 1819 Application of inlet control devices and dual drainage modelling for new subdivisions. P.E. Wisner, H. Fraser, C. Kochar, & C. Rampersad, pp 275-294
- 1820 Use of continuous SWMM for selection of historical rainfall design events in Tallahassee. W.C. Huber, B.A. Cunningham, & K.A. Cavender, pp 295-321
- 1821 An expert system prototype for RECEIV-II using Turbo Pascal. R.E. Dickinson, I.B. Chou, & F.V. Ramsey, pp 322-325
- 1822 Modelling flood hydrology using HYMO. J.E. Scholl, pp 326-331
-

19 September 1986:

Part 1

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Part 2

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20 March 1987:

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21 October 1987:

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22 October 1988:

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- 2205 Urban Runoff Modelling for Administrative Purposes. W.P. Ruzzo, pp 43-51
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- 2222 Gulf Coast Flood Routing. R.L. Rossmiller & K.R. Wright, pp 224-231